Bioclimatic-driven future shifts in dryland agroecological classes

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Climate change may result in substantial geospatial shifts in dryland cropping systems or agroecological classes (AECs). To analyze these potential shifts, we first successfully predicted current AECs based on land use/cover using bioclimatic variables. We then used identified bioclimatic AEC predictors in conjunction with future climate scenarios to project potential shifts in dryland AECs for the coming century.

Since 2007, the National Agricultural Statistics Service (NASS) has annually produced a cropland data layer of actual land use/cover (Figure 1) for the continental United States. We used the available annual cropland data layers to classify the REACCH study region into four major AECs: (1) dryland annual cropping (limited annual fallow), (2) annual crop-fallow transition (e.g., three-year rotations with fallow every third year), (3) grain-fallow (e.g., two-year rotation), and (4) irrigated. Our main objectives were to (1) identify important bioclimatic predictors that can discriminate among current dryland AECs and (2) use identified bioclimatic variables with future climate scenarios to predict potential shifts in dryland AECs. To achieve these objectives, we used current AECs (2007 through 2013) in the statistical variable selection process (discriminant analysis) to identify bioclimatic variables that significantly affect actual land use. Geographic information system software (ArcGIS) was integrated with statistical software "R" to process the AEC and climate data.

IMPACT

Our analysis found that climate change could cause substantial increases in the geospatial extent of the annual crop-fallow transition agroecological class (AEC) at the expense of the annual crop AEC. This shift could negatively affect cropping system diversification and intensification, soil organic matter, and soil vulnerability to erosion processes in the future.

Table 1. *Number of pixels (2.5 × 2.5 miles) classified in each AEC for present and future scenarios.*

	Stable AECs			Dynamic AECs		
Time period	AC*	AC-T*	GF*	AC	AC-T	GF
Present (2007–2013)	195	194	530	116	197	260
Predicted present	196	184	539	100	192	281
Correctness (%)	92.3	82.0	97.9	60.3	65.5	88.8
Future scenario (RCP -4.5)						
2026–2035	154	221	544	51	208	314
2056–2065	117	280	522	45	202	326
2086–2095	104	293	522	17	309	247
Future scenario (RCP -8.5)						
2026–2035	146	227	546	51	203	319
2056–2065	83	313	523	23	281	269
2086–2095	35	401	483	10	309	254

*AC: Annual crop
*AC-T: Annual crop-fallow transition
*GF: Grain fallow

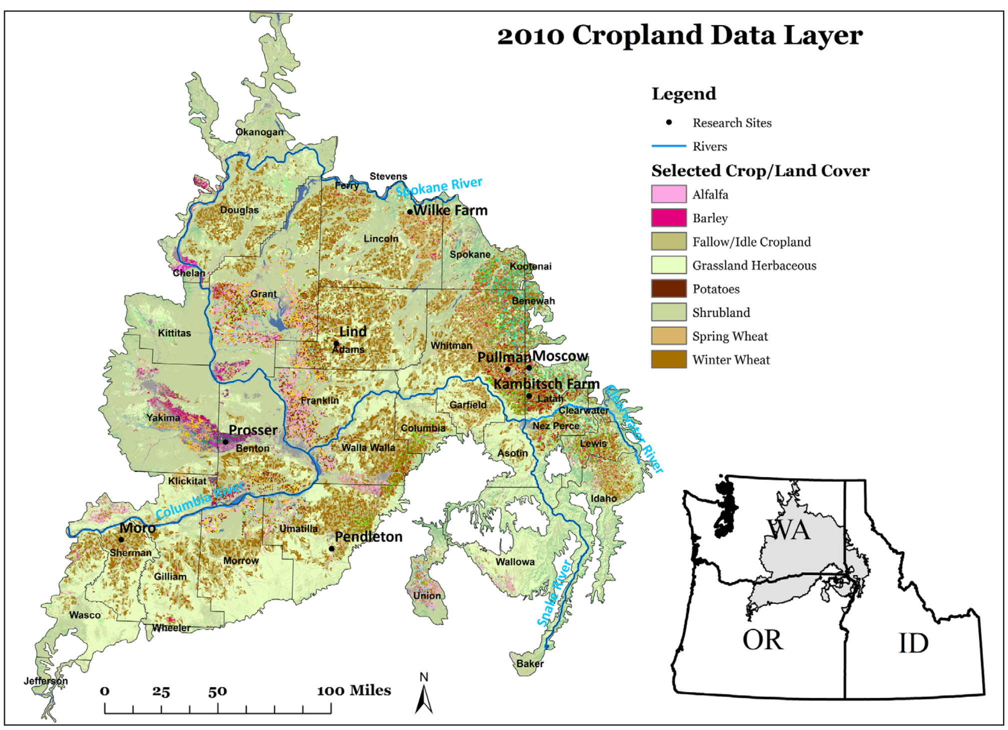

Figure 1. *Cropland data layer for the REACCH study area (National Agricultural Statistics Service, 2010).*

We scaled AEC data to climate data (2.5 × 2.5 miles) using the default nearest neighbor method in ArcGIS. To understand year-to-year dynamics between AECs, we further subcategorized classes into stable and dynamic AECs. Stable AECs did not change into any other class from 2007 to 2013. In contrast, dynamic AECs changed one or more times from 2007 through 2013 (Figure 2).

We calculated bioclimatic variables important in Mediterranean climates using actual 30-year (1981 to 2010) precipitation and temperature data. To reduce redundant information, we dropped variables using stepwise variance inflation in "R" software. We then conducted stepwise statistical discriminant analysis with "leave one out" cross-validation on the retained variables for stable and dynamic AECs. The preliminary analysis identified annual precipitation, growing degree days (January 1 through May 31), and percentage precipitation during March, April, and May and during September, October, and November as key bioclimatic predictors of AECs. Overall cross-validated misclassification error was 6% and 25% for stable and dynamic AECs, respectively. Finally, we used future climate data from 14 different global climate models to calculate the identified bioclimatic variables for three different time periods (2026 to 2035, 2056 to 2065, and 2086 to 2095) and two different climate change representative concentration pathways (RCPs): RCP 4.5 and RCP 8.5. Note: RCP 4.5 is the lower-emission scenario, and RCP 8.5 is the higher-emission scenario.

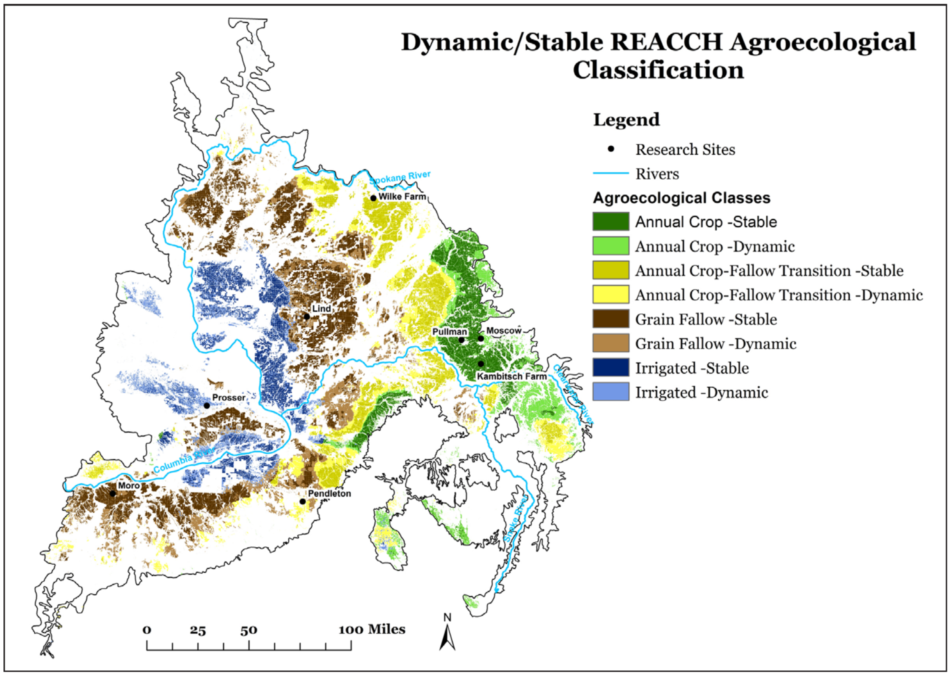

Figure 2. *REACCH agroecological classes for 2007 through 2013.*

Our preliminary analyses show that the annual crop AEC would decrease with the climate changes, converting into the annual crop-fallow transition AEC. The relatively stable grain-fallow AEC would be less affected by climate change than other dryland AECs (Table 1, Figure 3). The projected shift in AECs could significantly decrease cropping system diversification and intensification, reduce overall soil organic matter, and increase soil vulnerability to erosion processes.

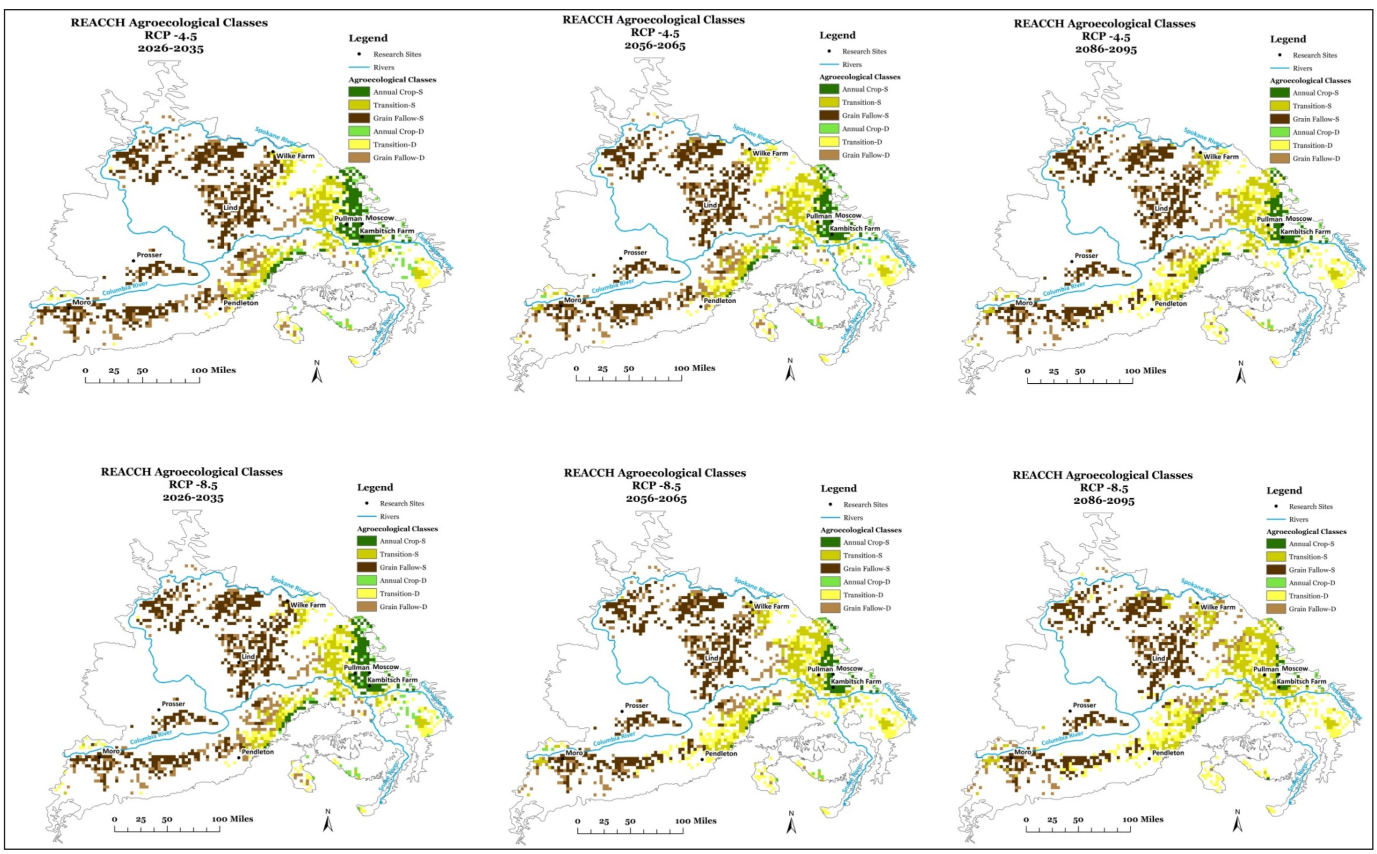

Figure 3. *Projected shifts in REACCH agroecological classes under different future scenarios.*